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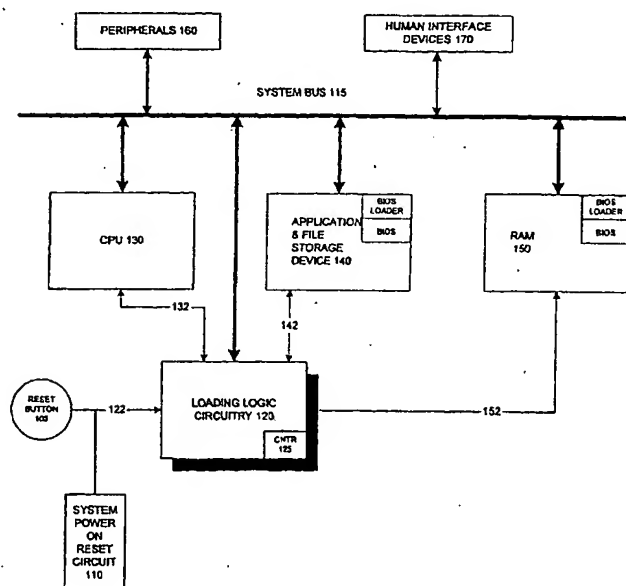
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(54) Title: SYSTEM AND METHOD FOR BOOTING FROM A NON-VOLATILE APPLICATION AND FILE STORAGE DEVICE



(57) Abstract: A system for booting a microprocessor controlled system wherein a basic interface between the processor and peripheral devices is copied from an application and file storage device into random access memory without usage of the microprocessor or need for a non-volatile code storage device.

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**SYSTEM AND METHOD FOR BOOTING FROM
A NON-VOLATILE APPLICATION AND FILE STORAGE DEVICE**

5

FIELD OF THE INVENTION

The field of the invention is microprocessor controlled devices, specifically
10 the initialization or booting process of the devices.

BACKGROUND OF THE INVENTION

A generic computing platform consists of various hardware and software
components. A main processor which contains a central processing unit (CPU), e.g.,
15 a microprocessor, is connected to a non-volatile code storage device (CSD), non-
volatile application and file storage device (AFSD), random access memory (RAM)
and other peripheral devices. The hardware dependent software that is required to
initialize various hardware components is stored in the code storage device. In
personal computer (PC) architecture this software is known as the BIOS (Basic Input
20 Output System). The BIOS provides an interface between the operating system and
the hardware. The process of execution of initialization software by the CPU is
known as the "boot" process. A CPU can boot directly from a CSD, or in order to
achieve higher performance can boot from a copy of the content of the CSD in RAM.

The background of the invention describes operation of a PC for illustrative
25 purposes, but the invention relates more generally to starting operation of any
intelligent device, and is not limited to PC architecture.

Referring to Fig. 1, in a generic computing environment, two types of non-volatile storage devices are used. These non-volatile storage devices are used for code storage and for application and file storage. Typically a code storage device (CSD) 45 has a much smaller capacity than an application and file storage device (AFSD) 40. In addition, a CSD is usually accessed after system power up or after system reset and its content is very infrequently updated by the computer system in comparison to an AFSD that is updated frequently by the applications or users of the operating system.

Traditionally the CSD 45 is hardwired to the system bus and is mapped into a specific memory location. After the completion of system power up reset or system reset, the CPU 30 will look for its initialization code in this specific location of CSD 45. This initialization code is dependent on system architecture or hardware, and in PC architecture is known as the BIOS. In other architectures this initialization code is referred to as initialization firmware, boot firmware etc... Examples of CSDs are EPROM, Flash ROM, and OTP PROM. An AFSD is used in order to store an operating system, application programs or general file and user data. An AFSD is a non volatile storage device such as solid state memory or a magnetic or optical drive

The BIOS or booting firmware is normally stored in the CSD 45 in order for the CPU to execute its instructions. Traditionally if boot code is stored in the AFSD 40, a small set of instructions, constituting the basic BIOS must be stored in the CSD 45 in order to copy the BIOS or booting firmware into system RAM 50. In this invention, the requirement of the CSD for storing and executing these initialization instructions is eliminated.

SUMMARY OF THE INVENTION

In the system of the present invention, without using the microprocessor to execute a set of instructions or changing system architecture, a smart logical interface circuit controls the computer system in order for an Application and File Storage Device (AFSD) to substitute for the functionality of the Code Storage Device (CSD). The circuitry loads the BIOS from the AFSD into Random Access Memory (RAM). An AFSD is a non-volatile memory storage device such as a solid state memory or a magnetic or optical drive. Upon its completion, the microprocessor then takes over the control and completes the system initialization process. Therefore there will not be any need for a CSD to store the BIOS. This initial loading logic circuitry (LLC) controls the initial loading of boot code. The LLC copies at least a sufficient amount of programming instructions from an AFSD into RAM to then allow a microprocessor to read the instructions, interface with the hardware, and take over operation of the system. These instructions are known as the BIOS in the specific embodiment of the PC used to illustrate the operation of the present invention, however in other platforms it may be referred to as firmware. The subset of the BIOS copied by the LLC is referred to as the "BIOS loader". However, the LLC has a much wider range of application than in PC architecture and the PC and its associated terms are only used for illustrative purposes. The LLC has applications in computing platforms ranging from small handheld devices such as digital cameras, personal audio players, personal digital assistants and sophisticated embedded systems such as telecommunication and networking equipment.

When the device power is turned on or the user presses a reset button, the microprocessor of the system executes the BIOS or firmware starting at a designated location in the system memory. If the microprocessor receives a HOLD or HALT it

releases control of the ADDRESS, DATA, and other control lines. In this invention, the HOLD is either generated immediately after or simultaneously with the RESET. After the microprocessor is put on hold, the LLC selects one of the multiple BIOS storage locations that is preset and stored in registers of the LLC. The BIOS storage location is defined by the LLC, and can easily be relocated for various processors that may require different BIOS storage locations. In addition, multiple BIOSs can be stored in the AFSD and accessed by the LLC, thus the user can select a different BIOS for a different purpose and the system can be configured differently upon startup for different purposes. Once the AFSD is enabled, the BIOS loader is copied from the AFSD into RAM. Thereafter, the LLC releases the HOLD/RESET of the microprocessor and the microprocessor can execute the BIOS loader from RAM. In addition, after completion of the booting process, the Loading Logic Circuitry activates its write protect circuitry for protecting the BIOS or boot code portion of the AFSD. This will protect the BIOS or boot code portion from accidental overwriting or erasing. This protection can be overridden only by an authorized user.

Thus, a dedicated ROM chip can be eliminated from the system because the microprocessor need not access the BIOS instructions that are normally saved therein.

The above process assumes there is a HOLD or HALT type of signal to the microprocessor and the microprocessor will make the ADDRESS, DATA and control lines tri-stated. If the required signals cannot be tri-stated or there is no HOLD or HALT function to the microprocessor, tri-state buffers may be used to isolate the system bus used by the microprocessor from the buses used for the copying process.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a prior art PC system using the conventional code storage device BIOS storage.

FIG. 2 is a block diagram of the components of the system.

5 FIG. 3 is a diagram of the Application and file storage device of Fig. 2.

FIG. 4 is a flow chart of the operation of the system.

FIG. 5 is a Detailed block diagram of loading logic circuitry 120 of Fig. 2.

FIG. 6 is a Detailed block diagram of the write protect generator 128 of Fig. 5.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

10 Referring to Figures 2-6, the operation of the system of the present invention will be shown. Operation of the system is illustrated by using an example of NAND flash memory for the non-volatile application and file storage device (AFSD) 140 of Fig. 2 for descriptive purposes, however, the invention encompasses any type of non-
15 volatile memory. This exemplary embodiment illustrates the system implemented with PC architecture, however the system of the present invention encompasses the startup of any intelligent device. The system has applications in many types of personal electronic devices such as music players/recorders, digital cameras, digital organizers, cellular phones, and a variety of other sophisticated embedded systems
20 such as Telecommunication and Networking equipment.

In Figure 2 the components of the system are illustrated. Loading Logic Circuitry (LLC) 120 is connected to reset button 105 and system power on reset circuit 110 by signal line 122. LLC 120 has an internal counter 125. System bus 115 is connected to LLC 120, CPU 130, AFSD 140, volatile random access memory
25 (RAM) 150, peripherals 160, and human interface devices 170. Peripherals 160 can

be printers or other output devices as well as additional drives and any other peripherals that are well known in the art. Human interface devices are things such as a keyboard, monitor, mouse, microphone or speakers and are likewise well known in the art. Control signal lines 132 connect LLC 120 with CPU 130, and control signal

5 lines 142 connect LLC 120 with AFSD 140. In this illustrative example control signal lines 142 are connected to the control inputs of the NAND flash memory. Additional control signal lines 152 connect LLC 120 and RAM 150. RAM 150 has a portion of memory allocated for storage of the BIOS 200 and the BIOS loader 200a, a portion of the BIOS. The BIOS and the BIOS loader in RAM 150 is a copy of the

10 BIOS and the BIOS loader in AFSD 140.

Figure 3 shows AFSD 140 in more detail. AFSD 140 is used to store user files, such as documents, pictures or drawings, and music files as well as executable system files. This application and file storage device is also utilized to store BIOS 200 and the BIOS loader 200a of BIOS 200. The remainder of AFSD 140 comprises

15 file storage portion 210. BIOS 200 only utilizes a relatively small proportion of AFSD 140 which has a capacity large enough to store a large number of files. For example AFSD 140 could have a capacity anywhere from 4 megabytes to several gigabytes.

Figure 4 shows the operation of the system components illustrated in Figure 2.

20 A system reset is triggered by either reset button 105 or by introducing or interrupting system power that triggers the system power on reset circuitry 110 in step 310. Either pressing the reset button or turning on the power will trigger Loading Logic Circuitry (LLC) 120. LLC 120 can also be triggered by other routines to reset the device. LLC120 comprises a finite state machine that controls the operation of the basic

25 initialization process through logic circuitry either on board level components, or on

application specific integrated circuitry (ASIC) such as a field programmable gate array (FPGA) or programmable logic device (PLD). Control of the basic initialization operation is not through a microprocessor such as a CPU.

After LLC 120 receives the system reset signal, it commences the

5 RESET/HOLD process and suspends the operation of CPU 130 through control signal lines 132 in step 320. After the operation of CPU 130 has been suspended, LLC 120 records the location of BIOS 200 in AFSD 140 in step 325. LLC 120 then initiates and readies the AFSD 140 through control lines 142 for sending data over system bus 115 in step 330. LLC 120 also readies the RAM 150 to receive data through control
10 lines 152 in step 330. Counter 125 is initialized to its preset initial value in step 330.

Next, LLC 120 copies the BIOS loader 200a from AFSD 140 over the system bus 115 into volatile RAM 150 in step 340. Counter 125 is incremented after each copy of data from AFSD 140 to RAM 150 in step 340. The BIOS loader 200a is an amount of the BIOS 200 sufficient to allow the CPU to start the boot operation. Thus,
15 it must be sufficient to allow communications with and control over AFSD 140 and RAM 150. This can range anywhere from less than one page to ten pages and is preferably only one page, or 512 bytes of BIOS 200, when dealing with PC architecture. However, this amount could be on the order of tens of kilobytes in embedded systems. When BIOS loader 200a is more than 512 bytes error correction
20 code can be used, whereas when BIOS loader 200a consists of one page (or less), error correction code is unnecessary because the integrity of the first page is generally assured because of pre-selection of the memory areas during manufacturing and testing. In applications where the integrity of a larger memory segment is assured a larger size of data can be copied without error correction. Furthermore, error
25 correction code can be directly integrated and thus the integrity can be determined

during the copying process, allowing even greater amounts of error free data to be copied. AFSD 140 can be any type of non-volatile storage device such as a solid state memory, magnetic disk, optical disk, or tape drives.

In the preferred embodiment, AFSD 140 is NAND flash memory (NFM) and a
5 brief discussion of the controls signals of NFM follows. NFM has an 8-bit data bus and 7 control signals, i.e., CLE (Command Latch Enable), ALE (Address Latch Enable), CE (Chip Enable), WE (Write Enable), RE (Read Enable), RB (Ready_Busy), and WP (Write Protect). The DATA bus is connected to the system bus 115 and the control signals are transmitted via control lines 142.

10 To access the NFM, the CE signal has to be in active state before any other signal can become active. A COMMAND is then written into the NFM followed by an ADDRESS, if the ADDRESS is required. The COMMAND code and the ADDRESS are presented through the data bus, illustrated as a part of the system bus 115. The RB (Ready_Busy) signal will indicate a busy state after writing of some
15 commands or address. Subsequent operations are performed after RB indicates the ready state.

The content of the data bus contains a command if the CLE is active and the ALE is inactive. The content in the data bus contains data if the CLE and the ALE are in an inactive state. The content of the data bus is an address if the CLE is
20 inactive and the ALE is active. Writing of an address requires multiple cycles of the WE signal depending on the size of the NFM. Content in the data bus is stored into NFM on the trailing edge of the WE signal.

To read data from the NFM, CLE and ALE are set to an inactive state before RE is set to an active state. When RE is active, the content from the NFM is
25 presented to the data bus.

As shown in Fig. 3, AFSD 140 is used not only to store BIOS 200, but also to store various user files in file storage portion 210. Copying of the data is achieved by sending a read enable (RE) signal to AFSD 140 and a write (WR) signal to RAM 150 over control signal lines 142 and 152 respectively. At the same time, an address counter 125 within LLC 120 is enabled. The address counter starts to count from a preset value and continues to increment with each clock. The clock signal has a low portion and a high portion. The low portion is used for the RE signal of AFSD 140 to enable data transfer to the system bus 115 from AFSD 140, and at the same time is used for the WR signal of RAM 150. During low to high transition of the clock (rising edge of the clock) the data on the system bus 115 is copied into RAM 150 and the address counter is incremented. This copying of the data continues until the address counter reaches 01FFh which corresponds to the 512 bytes of BIOS loader in this example. After the BIOS loader has been copied AFSD 140 and RAM 150 are disabled by setting the CE signal of AFSD 140 and the CS signal of RAM 150 to an inactive state.

Upon the completion of copying of the BIOS loader into RAM 150, LLC 120 releases hold of the CPU in step 350. Thus all of the aforementioned activities were performed without involvement of the CPU.

With the CPU now active again, it is important that BIOS 200 cannot be overwritten by the CPU. In step 355 LLC120 enables a write protect generator to assure this cannot happen as will be described later with reference to Fig. 5.

Finally, with the BIOS loader once stored in AFSD 140 now located in RAM 150, in step 360 the CPU executes the BIOS loader and can now copy the remaining portion of BIOS 200 into RAM 150.

Figure 5 is a detailed block diagram of loading logic circuitry (LLC) 120 of Fig. 2. LLC 120 comprises reset circuit (RC) 121, AFSD code address selector (ACAS) 122a, RAM load address selector (RLAS) 122b, address register (AR) 123 for BIOS 200 storage blocks, sequencer 124 including AFSD & RAM control circuit 124a and RAM address counter 124b, and write protect generator (WPG) 128 for the BIOS boot blocks in AFSD 140.

Reset Circuit 121 receives a reset signal over control line 122 from reset button 105 or system power on reset circuit 110 as shown in Fig. 2. After receiving a reset signal over control line 122, reset circuit 121 generates and sends a signal or signals over control lines 132 depending on the type of microprocessor used. RC 121 sends signal(s) that will make the microprocessor 130 tri-state its data bus, address bus and some necessary control signals. After RC 121 releases the signal, the CPU 130 will start execution at a designated address. If a microprocessor 130 has no ability to tri-state its bus then tri-state buffers may be used in order to suspend operation of CPU 130 while LLC 120 controls the initialization sequencing.

The BIOS stored in AFSD 140 can be located in one of multiple selectable locations using ACAS register 122a. The selected storage location of the BIOS is latched into AR 123 during a reset generated by RC 121. This latched value 123lv is used by the sequencer 124 for the starting address of BIOS loader 200a and by WPG 128 for the block value where the BIOS is located. The location of the BIOS in RAM is also hardware selectable through RAM load address selector (RLAS) 122b.

Sequencer 124 is the sequential state machine that is initiated to start copying the BIOS loader 200a from AFSD 140 into RAM 150 starting at address 123lv specified by AR 123. This sequencer 124 includes AFSD & RAM control 124a and the RAM address counter 124b. The output of the RAM address counter 124b is used

as the address to RAM 150 during the loading process. The output of the RAM address counter 124b is tri-stated at the completion of the load process. At the end of the copying, CPU 130 is released via signal lines 132.

Figure 6 is a detailed block diagram of the write protect generator 128 of Fig.

- 5 5. WPG 128 comprises a command/control decoder 420, page address register 430, command code register 440, write strobe generator 450, and comparator logic 470 including boot code block address comparator 472 and command code comparator 474.

WPG 128 protects the data in the boot code blocks, i.e. where the BIOS 200 is
10 located in AFSD 140 so that any file or application is not written in the blocks where BIOS 200 is located, as seen in Fig. 3. If an attempt is made to write or to erase the boot code blocks of the AFSD, this generator will disable the strobe of the write enable to AFSD 140; it invalidates the operation and the write or erase operation is not performed.

15 Command/Control Decoder (CCD) 420 is a circuit that generates all necessary control signals to AFSD 140 over system bus 115. CCD 420 receives control signals from CPU 130 over the system bus 115, decodes the signals from the CPU, and sends the decoded signals over the control lines 142 to AFSD 140.

Page address register 430 maintains the address information for AFSD 140.
20 When CPU 130 of Fig. 1 sends a designated address to AFSD 140, it is latched into this page address register 430. When CPU 130 sends a command to the AFSD 140, it is latched into the command code register 440.

Write strobe generator 450 controls the writing of the memory cells of AFSD
140. When CPU 130 writes to AFSD 140, whether the write is a command, an
25 address or data, two write signals "WR_1" and "WR_2" are generated with one CPU

write operation. WR_1 is generated first, then WR_2 is generated shortly after.

WR_1 will latch the address and command code into the page register and command code register respectively for boot code block comparison. WR_2 is used as the WRITE ENABLE signal to AFSD 140.

- 5 Boot code block address comparator 472 compares the page address register 430 and the boot code block address 123lv. If the result is identical, the command code comparator 474 is enabled.

 Command Code Comparator 474 checks the content of the command code register with the command "PROGRAM", "ERASE" or other commands which will
10 modify the content of AFSD 140. If the content of the command code register is a "PROGRAM" or "ERASE" WR_2 will be disabled, and thus the program or erase operation will be prevented. Therefore, the BIOS 200 in AFSD 140 is protected from any modification.

 This system is advantageous in many ways over prior designs. The BIOS is
15 stored on a storage device that is used for application or file storage, and more importantly, a portion of the BIOS is copied from an AFSD into RAM without using a microprocessor executing commands located on a special purpose ROM. Thus, a dedicated chip such as the ROM, commonly used to store the BIOS in PCs, can be eliminated resulting in a substantial cost saving, smaller board size, and simplified
20 interface structures. Additionally, the BIOS can be more easily altered when it is stored in an AFSD.

 While an illustrative example of the invention has been shown and described, it will be apparent that other modifications, alterations and variations may be made by and will occur to those skilled in the art to which this invention pertains.

It is therefore contemplated that the present invention is not limited to the embodiments shown and described and that any such modifications and other embodiments as incorporate those features which constitute the essential features of the invention are considered equivalents and within the true spirit and scope of the

5 present invention.

IT IS CLAIMED:

1. A system for starting operation of an intelligent device comprising:
an application and file storage device configured to read and write data
files, one or more of the data files including the basic input/output system (BIOS)
5 interface;
random access memory (RAM);
a loading logic circuit that copies a portion of the BIOS from the
storage device into the RAM.
- 10 2. The system of claim 1 wherein the loading logic circuit is configured
to copy the portion of the BIOS from the application and file storage device into the
RAM without using a microprocessor.
3. The system of claim 1 wherein the application and file storage device
15 is a flash memory device.
4. The system of claim 1 wherein the application and file storage device
is a magnetic or optical disk drive.
- 20 5. The system of claim 1 wherein the loading logic circuit is contained in
a field programmable gate array(FPGA).
6. The system of claim 1 wherein the loading logic circuit is contained in
a programmable logic device.

7. The system of claim 1 wherein the circuit comprises board level components.
8. The system of claim 1 wherein the loading logic circuitry stores the BIOS at any location of the storage device.
9. The system of claim 1 wherein the loading logic circuitry copies the BIOS to any location in the RAM.
10. The system of claim 1 wherein the loading logic circuitry comprises a write protect mechanism that prevents the location of the storage device having the BIOS from being overwritten.
11. The system of claim 10 wherein the write protect mechanism generates a first and second write strobe signal for each write strobe signal of a microprocessor.
12. The system of claim 11 wherein the first write strobe signal is separated from the second write strobe SIGNAL by a period of time, and wherein the first write strobe signal records the location of the BIOS in the storage device and the command code to the storage device, and the second write strobe signal enables writing of the storage device.
13. The system of claim 12 wherein when the microprocessor attempts to write to the location of the BIOS in the storage device, the second write strobe signal is not generated whereby the BIOS is not overwritten.

14. A method of starting a smart device comprising:
resetting operation of a microprocessor; and thereafter
suspending operation of the microprocessor; and thereafter
5 copying a portion of a BIOS from an application and file storage
device into RAM; and thereafter
starting operation of the microprocessor.
15. The method of claim 14 wherein the storage device includes multiple
10 BIOSs and wherein a user can select which BIOS to copy from the application and
file storage device into RAM.
16. The method of claim 14 further comprising the step of reading the
portion of the BIOS from the RAM with the central processing unit after the step of
15 starting operation of the microprocessor.
17. The method of claim 14 wherein the step of copying the BIOS from a
memory storage device into RAM is controlled by a state machine.
- 20 18. The method of claim 17 wherein the state machine is implemented in
an ASIC.
19. The method of claim 17 wherein the state machine is implemented in
an FPGA.

20. The method of claim 14 wherein the application and file storage device is a flash memory device.

21. The method of claim 14 wherein the application and file storage device
5 is a magnetic or optical drive.

22. A method of providing an interface between an operating system and hardware devices comprising:
storing the interface in an application and file storage device; and
10 thereafter
copying the interface from the application and application and file storage device into RAM without using a microprocessor.

23. The method of claim 22 wherein the interface is a basic input output
15 system (BIOS)-of routines.

24. The method of claim 22 wherein the application and file storage device is a NAND flash memory device.

20 25. The method of claim 22 wherein the application and file storage device is a magnetic or optical drive.

26. The method of claim 22 wherein the step of copying the interface is controlled by a logic loading circuit.

25

27. The method of claim 26 wherein the circuit is implemented on board level components.

28. The method of claim 22 further comprising copying additional
5 interface device commands from the application and file storage device into RAM using the microprocessor.

29. The method of claim 22 wherein the step of copying the interface comprises:
10 enabling the application and file storage device and the RAM; and thereafter
enabling an address counter to output a value; and thereafter
correlating the value with a RAM address; and thereafter
sending data from the application and file storage device over a data
15 bus to the RAM address; and thereafter
incrementing the address counter.

30. The method of claim 22 wherein the step of copying the interface
further comprises the usage of error correction code.
20

31. A system for booting a microprocessor controlled device comprising:
an application and file storage device having a plurality of files ;
random access memory;
a microprocessor;
25 human interface devices; and

an interface for communicating between the microprocessor, the application and file storage device and the human interface devices, the interface residing in a file of the file storage device; and means for copying a portion of the interface into the random access memory without using the microprocessor.

32. The system of claim 31 wherein the application and file storage device comprises a non-volatile solid state memory device.

33. The system of claim 31 wherein the file storage device comprises an optical or magnetic disk drive.

34. The system of claim 31 further comprising a means for protecting the file on the file storage device from being overwritten.

35. The system of claim 1 wherein the loading logic circuit further comprises a means for protecting the basic input/output system (BIOS) interface on the application and file storage device from being overwritten.

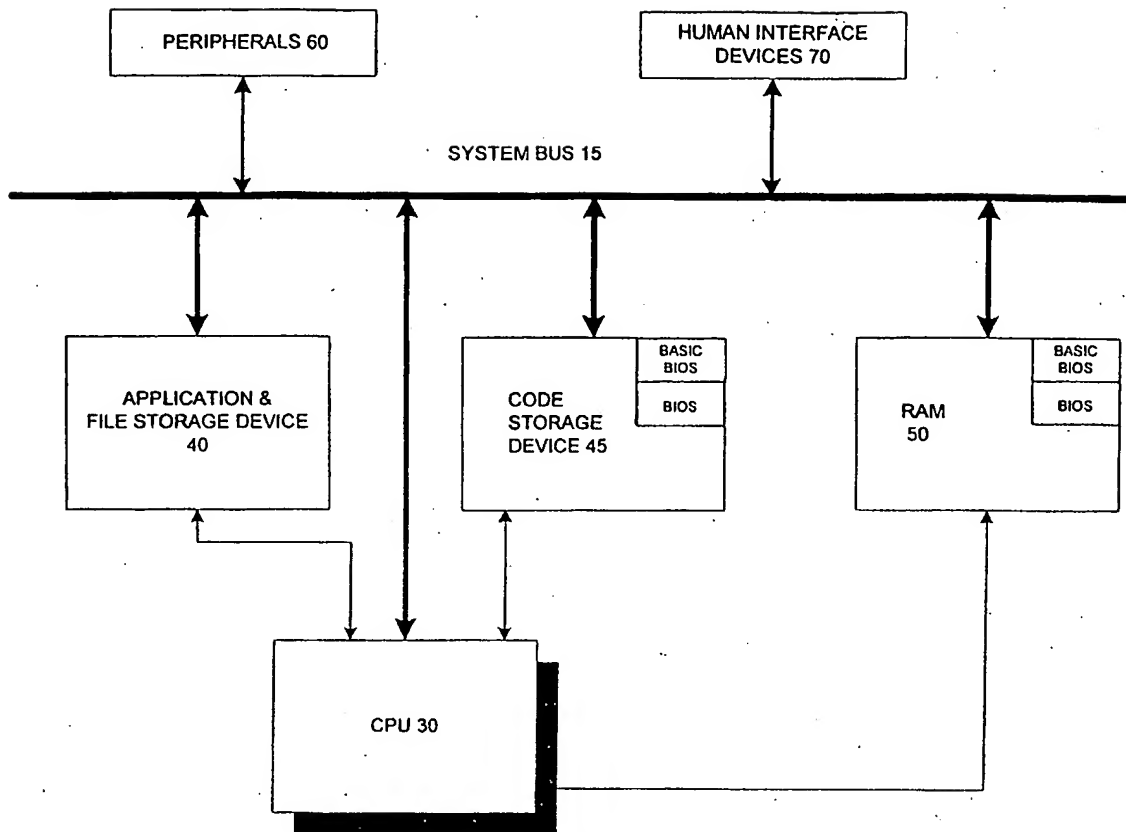


Fig. 1 - PRIOR ART

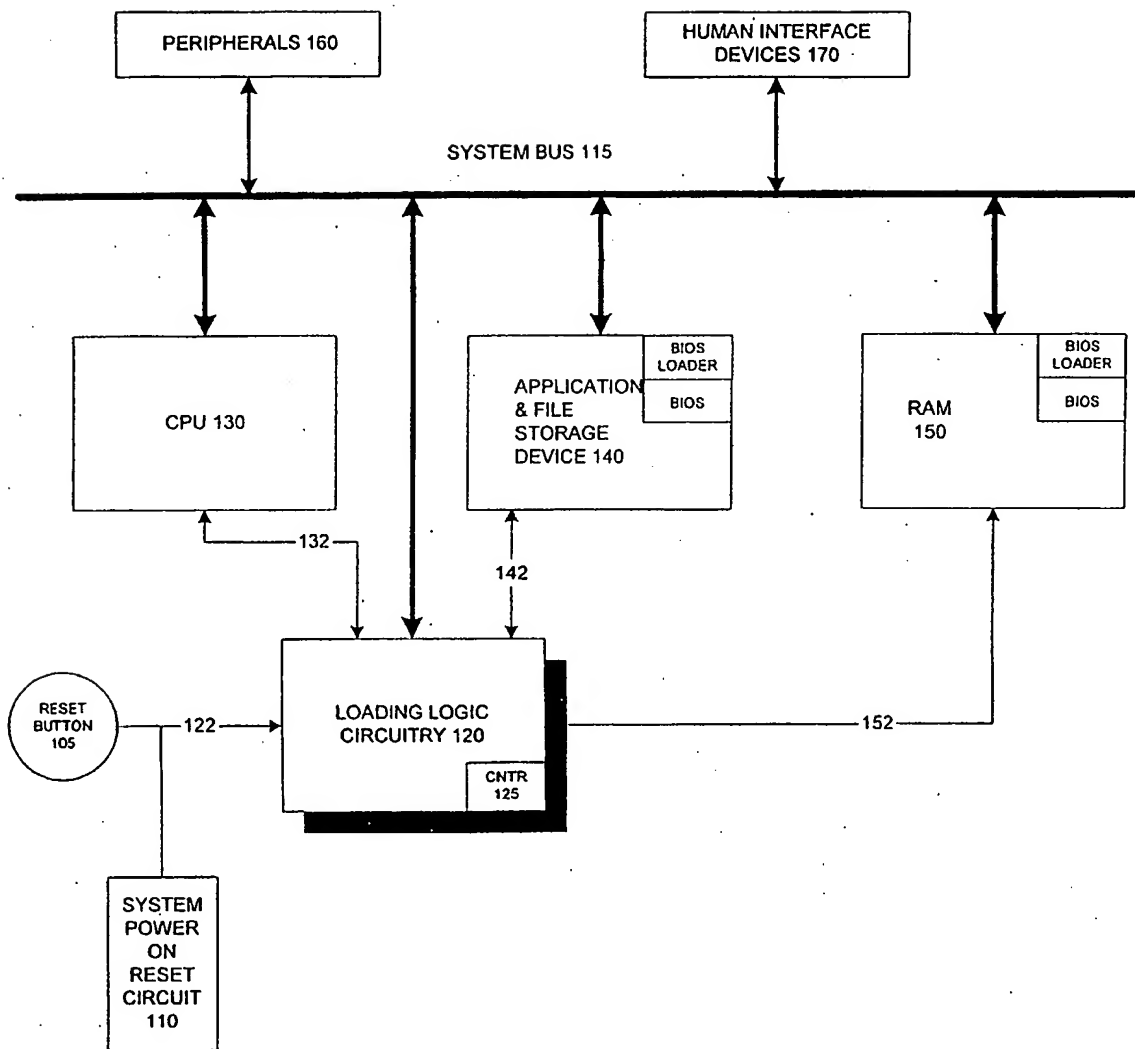


Fig. 2

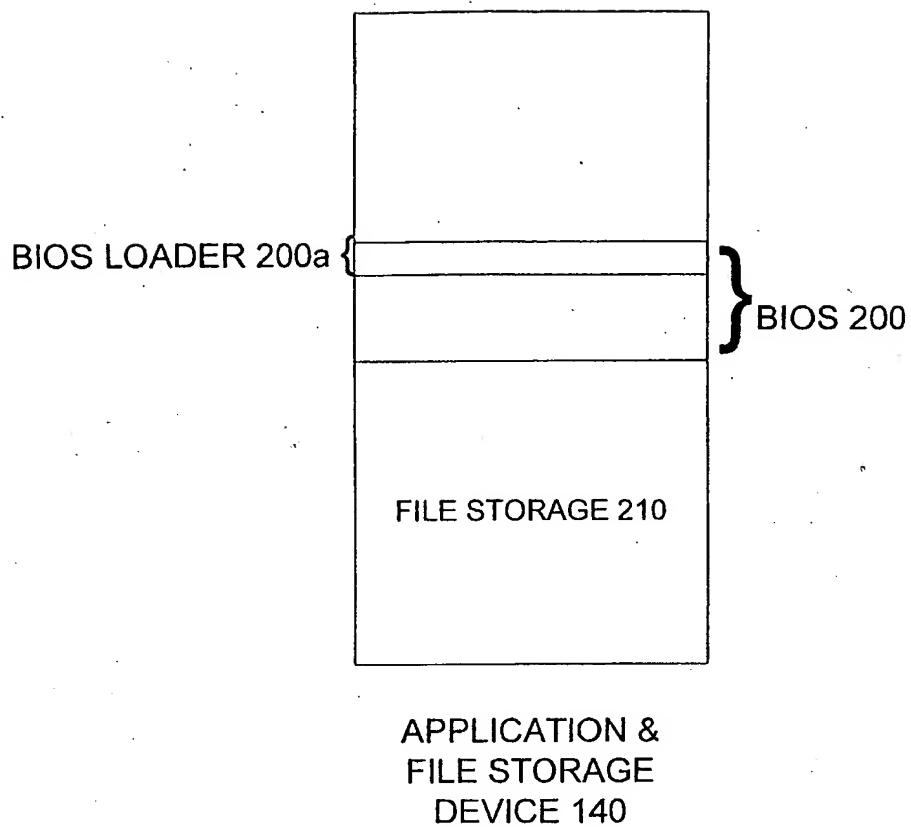


Fig. 3

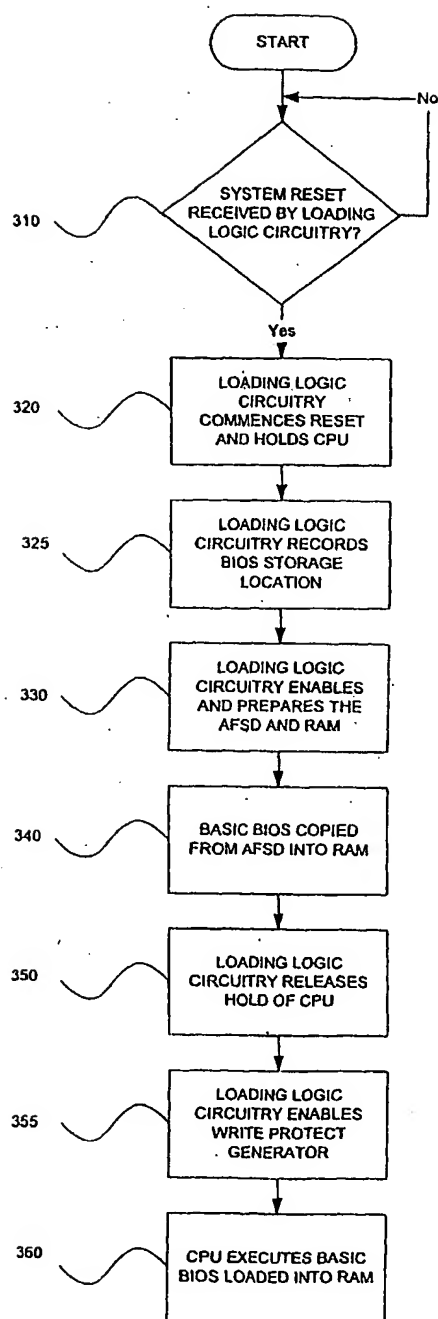


Fig. 4

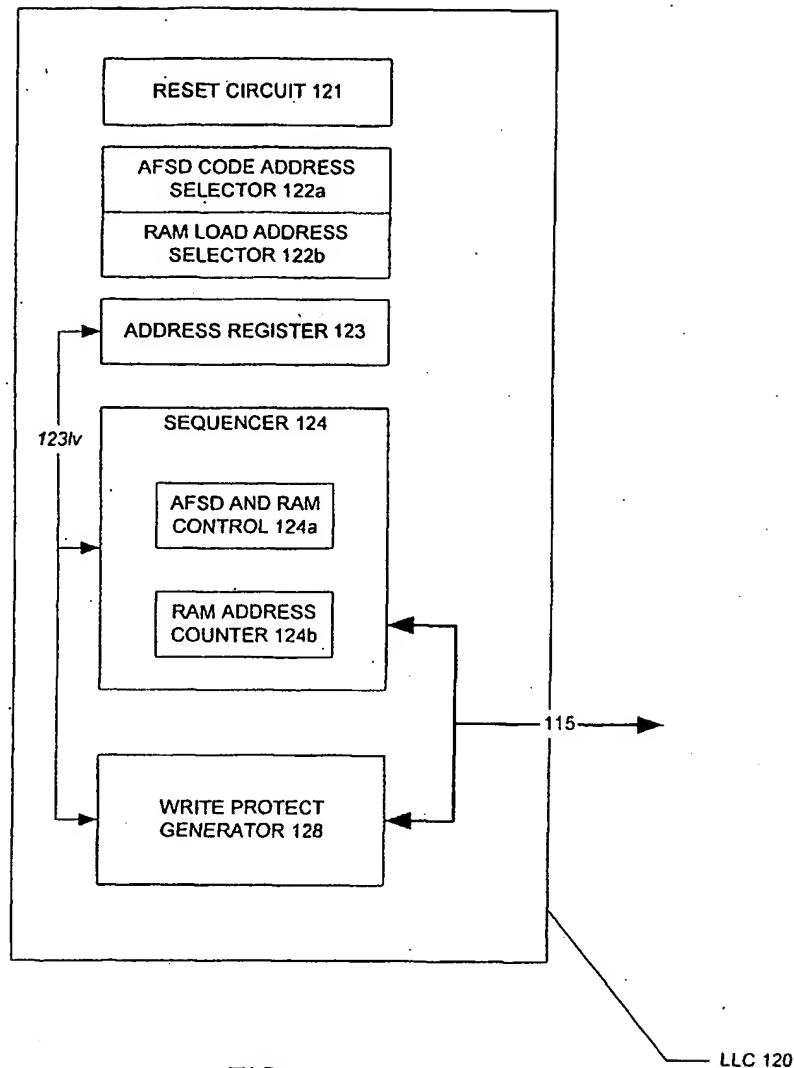


FIG. 5

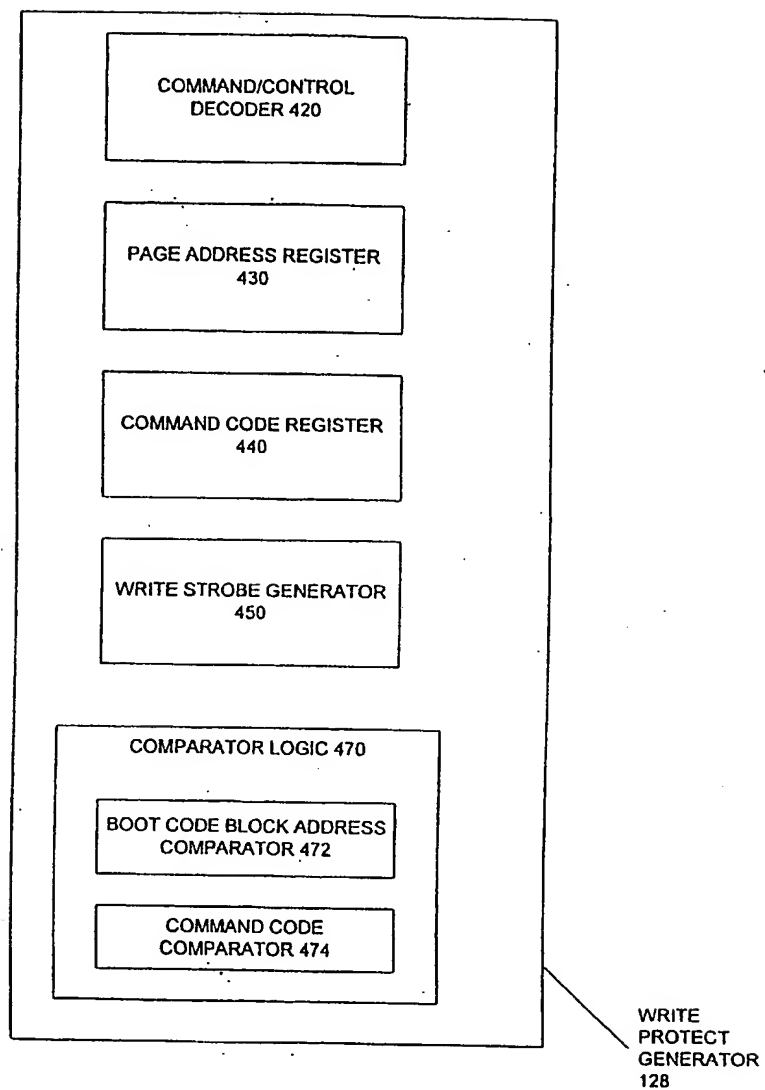


FIG. 6